HYDRATE RESEARCH ACTIVITIES THAT BOTH SUPPORT AND DERIVE FROM THE MONITORING STATION/SEA-FLOOR OBSERVATORY, MISSISSIPPI CANYON 118, NORTHERN GULF OF MEXICO

SEMIANNUAL PROGRESS REPORT
1 JANUARY, 2007 THROUGH 30 JUNE, 2007

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Task 4: Noise-Based Gas Hydrates Monitoring

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ABSTRACT

The Gulf of Mexico Hydrates Research Consortium (GOM-HRC) was established in 1999 to assemble leaders in gas hydrates research. The Consortium is administered by the Center for Marine Resources and Environmental Technology, CMRET, at the University of Mississippi. The primary objective of the group is to design and emplace a remote monitoring station or sea floor observatory (MS/SFO) on the sea floor in the northern Gulf of Mexico by the year 2007, in an area where gas hydrates are known to be present at, or just below, the sea floor. This mission, although unavoidably delayed by hurricanes and other disturbances, necessitates assembling a station that will monitor physical and chemical parameters of the marine environment, including sea water and sea-floor sediments, on a more-or-less continuous basis over an extended period of time. In 2005, biological monitoring was added to the mission of the MS/SFO as a means of assessing input and impact of microbial communities in the establishment and longevity of hydrates and is assessing environmental health.

Establishment of the Consortium has succeeded in fulfilling the critical need to coordinate activities, avoid redundancies and communicate effectively among researchers in the arena of gas hydrates research. Complementary expertise, both scientific and technical, has been assembled to promote innovative research methods and construct necessary instrumentation.

Initial components of the observatory, a probe that collects pore-fluid samples and another that records sea floor temperatures, were deployed in Mississippi Canyon 118 in May of 2005. Follow-up deployments, planned for fall 2005, had to be postponed due to the catastrophic effects of Hurricane Katrina (and later, Rita) on the Gulf Coast. Station/observatory completion, anticipated for 2007, will likely be delayed by at least one year.

The CMRET regularly conducts research cruises to the site of the MS/SFO at Mississippi Canyon 118 (MC118). During this reporting period, the Consortium arranged and conducted two cruises. The primary objective of a March cruise was to perform sea trials of the Station Service Device (SSD), the Remotely Operated Vehicle (ROV) designed especially to perform functions peculiar to the SFO. Further objectives included tests and recovery of geochemical and microbial instruments and experiments from the observatory site, using the SSD. A June cruise in shallow water, offshore Mississippi served as a test for the Borehole Line Array (BLA, BHA) in a horizontal configuration. Data acquired during this cruise are being analyzed by Texas, Bureau of Economic Geology (BEG), Exploration Geophysics Laboratory (EGL).

The seafloor monitoring station/observatory is funded approximately equally by three federal Agencies: Minerals Management Services (MMS) of the Department of the Interior (DOI), National Energy Technology Laboratory (NETL) of the Department of Energy (DOE), and the Seabed Technology Research Center (STRC), a division of the National Institute for Undersea Science and Technology (NIUST), an agency of the National Oceanographic and Atmospheric Administration (NOAA), Department of Commerce (DOC).

Noteworthy accomplishments of Consortium researchers funded with DOE's contributions to this multiagency effort during this six-months cycle include:

- Design and construction of the Horizontal Line Arrays (HLAs):
  - Discussions among geophysicists working within the Consortium have resolved remaining spacing and other configuration issues associated with this critical station component.
  - Both I/O and SDI wrote software to resolve remaining HLA communications issues.
  - The new combination of cards and software was packaged and tested at sea with the MMRI Sled combination S- and P-wave source in June. The in-water test was performed using multiple configurations with successful recovery of accelerometer shear data generated from the CMRET-developed seismic-gun shear-sled.

- Seismic Data Processing at the Gas Hydrate Sea-floor Observatory: MC118:
  - Researchers have developed and tested software that allows sensor-calibrated 4C OBS data to be used to make improved P-P and P-SV images of near-seafloor geology.
  - The first field test of the seismic data-acquisition system was done, and shallow-water test data are now available for analysis.

- Coupling of Continuous Geochemical and Sea-floor Acoustic Measurements:
  - SDI has built the third PFA sampler box with modifications that include enclosing the valve in an oil box to isolate it from sea-water and adding a new valve lever arm to allow a submersible vehicle to close the valve on the seafloor.
  - FSU is in the process of building 12 new osmosamplers.
  - FSU has tested the OsmoSamplers collected during the first deployment of the PFA to verify their post-deployment pumping rates in order to better quantify the time series.
  - Geochemical analyses of sulfate, methane, chloride, and isotopes recovered *via* the original PFA deployment in 2005 to investigate specific features at MC-118 identified by geophysical data have been completed.
  - One of the peepers deployed at MC118 in September 2006, near outcropping hydrate and a bacterial mat, was collected in March 2007, using the Station Service Device (SSD). Methane concentrations were 100uM closest to the hydrate, increasing to 325uM 10cm distant, suggesting a methane sink closest to the hydrate.

- Noise-Based Gas Hydrates Monitoring:
  - Efforts to analyze time-series data acquired with the storm monitor in MC118 have begun; details of wave-noise can be recovered.
  - The principle investigator is a key participant in the discussions aimed at determining the optimal configuration of the horizontal arrays that will comprise a major component of the sea floor observatory. This effort

is, essentially, resolved and therefore, complete.

- Administration of the Monitoring Station/Sea-floor Observatory project this reporting period has consisted of
  - Organizing and hosting a February meeting of the Consortium held in Oxford, MS and attended by 50 Consortium members.
  - Organizing and carrying out a March cruise aboard the R/V *Pelican* to test the capabilities of the Consortium-designed and built robotic Station Service Device (SSD).
  - Organizing and carrying out a June cruise to test the prototype Horizontal Line Array, including the use of the CMRET shear-sled for producing shear-wave data.
  - Reporting to and interacting with sponsoring agencies and their officers as well as with Consortium members. The semiannual progress report, 42877R02 was completed and submitted in March and the semiannual progress report, 41628R18 was completed and submitted to DOE in June, 2007. Monthly reports have been made to DOE each month of the reporting period. Documents were generated and compiled to create a CD of the Annual Meeting which was distributed to meeting attendees in May.
  - Wall-to-Wall, an independent television programming production company, accompanied Consortium participants on the September, 2006 *Seward Johnson*/Johnson SeaLink cruise to MC118 cruise so that they might film portions of the cruise for inclusion in a miniseries for Discovery Television. They filmed portions of the visual surveying of MC118 as well as some of the deployments, recoveries, and related activities. The broadcast of the Energy segment of *Building the Future* aired in June, 2007.

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LIST OF GRAPHICAL MATERIALS

Graphical materials used to illustrate reports can be found in the individual reports submitted by the subcontractors.

INTRODUCTION / PROJECT SUMMARY

The Gulf of Mexico-Hydrate Research Consortium (GOM-HRC) is in its seventh year of developing a sea-floor station to monitor a mound where hydrates outcrop on the sea floor. The plan for the Monitoring Station/Sea Floor Observatory (MS/SFO) is that it be a multi-sensor station that provides more-or-less continuous monitoring of the near-seabed hydrocarbon system, within the hydrate stability zone (HSZ) of the northern Gulf of Mexico (GOM). The goal of the GOM-HRC is to oversee the development and emplacement of such a facility to provide a better understanding of this complex hydrocarbon system, particularly hydrate formation and dissociation, fluid venting to the water column, and associated microbial and/or chemosynthetic communities. Models developed from these studies should provide a better understanding of gas hydrates and associated free gas as: 1) a geo-hazard to conventional deep oil and gas activities; 2) a future energy resource of considerable significance; and 3) a source of hydrocarbon gases, venting to the water column and eventually the atmosphere, with global climate implications.

Initial funding for the MS/SFO was received from the Department of Interior (DOI) Minerals Management Service (MMS) in FY1998. Funding from the Department of Energy (DOE) National Energy Technology Laboratory (NETL) began in FY2000 and from the Department of Commerce (DOC) National Oceanographic and Atmospheric Administration's National Undersea Research Program (NOAA-NURP) in 2002. Some ten industries and fifteen universities, the United States Geological Survey (USGS), the US Navy, Naval Meteorology and Oceanography Command, Naval Research Laboratory and NOAA's National Data Buoy Center are involved at various levels of participation. Funded investigations include a range of physical, chemical, and, more recently, microbiological studies.

EXECUTIVE SUMMARY

A consortium has been assembled for the purpose of consolidating both the laboratory and field efforts of leaders in gas hydrates research. The Consortium, established at and administered by the University of Mississippi's Center for Marine Resources and Environmental Technology (CMRET), has, as its primary objective, the design and emplacement of a remote monitoring station on the sea-floor in the northern Gulf of Mexico by the year 2007. The primary purpose of the station is to monitor activity in an area where gas hydrates are known to be present at, or just below, the sea-floor. In order to meet this goal, the Consortium has begun assembling a station that will monitor physical and chemical parameters of the sea water, sea-floor sediments, and shallow subsea-floor sediments on a more-or-less continuous basis over an extended period of time. Central to the establishment of the Consortium is the need to coordinate activities, avoid redundancies and promote effective and efficient communication among researchers in this growing area of research. Complementary expertise, both scientific and technical, has been assembled; collaborative research and coordinated research methods have grown out of the Consortium and design and construction of most instrumentation for the sea-floor station is essentially complete.

The MS/SFO was designed to accommodate the possibility of expanding its capabilities to include biological monitoring. A portion of FY04 funding from the MMS was directed toward this effort to support the study of chemosynthetic communities and their interactions with geologic processes. In addition, results will provide an assessment of environmental health in the area of the station. NOAA-NURP has, as a focal point, investigations of the effects of deep sea activities on world atmosphere and therefore, weather. In July of 2005, the Director of the National Institute for Undersea Science and Technology (NIUST) of NOAA-NURP made a portion of that agency's budget available, *via* competitive grants, to researchers with proven expertise in microbial research. A sea-floor microbial observatory is an objective of that agency and these sponsored projects sited at the MS/SFO are designed to fulfill that directive.

The centerpiece of the observatory, is a series of vertical and horizontal line arrays of sensors (VLA, HLAs) designed to detect shifts in the hydrate stability zone (HSZ). The VLA is to be moored to the sea floor and to extend approximately 200 meters from the sea-floor into the water column. Sensors in the VLA include hydrophones to record water-borne acoustic energy (and measure sound speed in the lower water column), thermistors to measure water temperature, tilt meters to sense deviations from the vertical induced by water currents, and compasses to indicate the directions in which the deviations occur. The prospective horizontal water-bottom arrays, will consist of hydrophones and will be laid upon, and pressed into, the soft sediment of the sea-floor. They will be arranged into a cross with four 500m-long arms so that they simulate two perpendicular arrays, with each of the two directions approximating the water depth at the observatory site. Their deployment will be accomplished by means of a sea-floor sled designed to lay cable and deploy probes into shallow, unconsolidated sediments. This sled will also be used as a seismic source of compressional and shear waves for calibrating the subsurface seismo-acoustic array commissioned by the Joint Industries Program (JIP). It is anticipated that accelerometers will be implanted in the vicinity of the HLAs in the future, thus making it possible to image the HSZ to greater depths and to see interstitial space occupied by gas (as shown by hydrophone data, which do not travel through gas).

The prototype DOE-funded VLA has been completed and tested together with the associated data-logging and processing systems. The NOAA/NURP/NIUST-funded Bubble Counter, Oceanographic Benthic Boundary Layer Array (BBLA), Chimney Sampler Array (CSA), - equipped with a variety of sensors: thermistors, fluorometers, oxygen sensors, transmissometers, mass spectrometers, conductivity and current flow meters – have been deployed at the observatory site, and recovered at MC118 via the Johnson SeaLink. Processing techniques continue to be developed for vertical array data by Consortium participants who are currently funded by the MMS.

A Remotely Operated Vehicle (ROV) mateable connector system was designed and installed in the VLA Data Acquisition and Telemetry System (DATS) deployed in 2005. This improved design has been incorporated into the VLA and the Oceanographic Line Array (OLA) components of the observatory. Positioning sensors – including compass and tilt sensors – have been completed and tested. Pressure housings rated twice that of any anticipated deployment have been built and pressure tested.

In May, 2005, the Sea-Floor Probe (SFP) was used to retrieve core samples from MC118 as part of the effort to select sites appropriate for deployment of the thermistor and geochemical probes. The northwestern portion of the mound area defined on images recovered during a C&C autonomous underwater vehicle (AUV) survey April 30-May 2, 2005, was selected for probe deployments based on information from these cores. Both the pore-fluid array and the thermistor array were deployed *via* SFP at MC118 in May, 2005.

A complete surface-source/deep-receiver (SS/DR) survey of the mound at MC118 has been made and a drift camera designed, deployed and used successfully to survey the sea-floor, visually. The SS/DR survey consists of north-south lines spaced 50m apart and east-west lines at 100m spacing over the mound at MC118. The resultant 109 profiles of very high resolution seismic data have undergone preliminary processing to create a 3-D model of the mound. Normal-incidence reflection seismic traces recorded over the mound were obtained using an $80in^3$ watergun source at the water surface and a single hydrophone deep-towed (350-400m) vertically below the source. The data set is expected to describe the interior of the mound to a depth of more than 300m below the sea floor with vertical resolution on the order of a meter. Results are expected to be sufficient to describe the entire hydrate stability zone in the vicinity of the mound. The 30,000-trace data set has been processed using source-signature phase conjugation, spherical-divergence corrections and a high-cut filter to attenuate the noise in the shallow section. The amount of attenuation achieved was less than desired, however, and the filter produced undesired phase shifts. It was decided to redo the processing using the method of Empirical Mode Decomposition described by Battista et al. (2007).

Following several "false starts", anticipating the use of other vessels which never did become available, the CMRET eventually secured seven days of ship time aboard the R/V *Seward Johnson* with use of its manned-submersible, the Johnson SeaLink. This vessel combination was used to retrieve the osmopump packages and data-loggers deployed in 2005, to conduct visual surveys of the observatory site at MC118 and to deploy sensors and experiments. Experiments designed to assess water-column geochemistry, microbial communities and activities, hydrate host materials, and composition of pore-fluids were left on the sea-floor for several months' data collection.

The Pore Fluid Array, which had been installed in May, 2005, was located on the first dive of the September *Seward Johnson*/Johnson SeaLink cruise, upright and protruding from the sediments by about 2 meters. The osmo-pumps and sampling loops were recovered and a replacement box and pumps were interfaced to the PFA device on a subsequent dive.

A second PFA osmosampler was placed on the sea-floor near the southwestern crater at the site designated "Rudyville". Pore water equilibrators or "peepers" were installed at three sites at MC118. In addition to samples and data collected from these instruments, methane concentration and isotope samples were collected from 8 cores that were collected using the SeaLink at a variety of sites along transects across microbial mats.

Acoustic wipe-out zones may be indicative of active methane venting from sediments containing gas hydrate. Analysis of data recovered from the Pore-Fluid Array and the Geophysical Line Array (GLA) indicate that the pore-fluids at 8.5m depth are many times brinier than "normal" pore-fluids and are likely inhibiting the formation of hydrates and diminishing the extent of the hydrate stability zone in the area of the northwest vent on the mound at MC118.

Analyses of cores from MC118 have been made and reveal that these cores are isotopically lighter than the vent gas, suggesting microbial methane production in the surface sediments. The dissolved methane in the porewaters is a mixture of biogenic and thermogenic sources, with more biogenic methane near the surface. Three cores are depleted in sulfate within 10 cm of the sediment-seawater interface. Although the average sea-water chloride concentration varies, brine was not present within the surface sediments.

Sediments collected from Mississippi Canyon have been studied for effects of parameters possibly involved in hydrate formation. The sediments vary in mineral composition as well as in grain size. They also vary in the extent and variety of microbial activities that occur in them, suggesting diverse bioproducts.

Smectite clays promote hydrate formation when basic platelets slough off the clay mass. These small platelets act as nuclei for hydrate formation. Anionic bioproducts may collect in the interlayers of the platelets and become involved in the mechanism of hydrate promotion.

It remains unclear exactly how particle size/size distributions affect hydrate formation. It is thought that the variety of bioproducts existing with depth in the sediments may mask particle size effects—that is, some bioproducts may promote hydrate formation and others may coat particles and retard hydrate formation.

Members of the Consortium's geophysical team, including Specialty Devices Inc. and CMRET, in cooperation with EGL and UCSD conducted a test of the 4-C prototype horizontal line array in June, 2007, offshore Biloxi, MS. The test was unique in that it featured an advanced accelerometer design, demonstrating its effectiveness for incorporation in a 4-component, hydrophone and accelerometer (for p- and s-wave reception, respectively) passive seismic array net work. The in-water test was performed with new circuitry and software and resulted in successful recovery of accelerometer shear data generated from the MMRI-developed seismic gun shear-sled. Multiple accelerometer sensors coupled with multiple hydrophone sensors were used to simulate down-hole arrays or deep-sea HLAs. Shear phones were installed in 3 different ways and multiple data lines shot varying shot-point offsets and spacings and recovering data with excellent signal–to-noise ratios. This new variant/concept in seismic array design will enable the use of natural surface noise (via hydrophone) and microseism noise from salt movement (via accelerometer). The goal is to use these passive seismic sources for long-term monitoring of structural and hydrocarbon fluid dynamics in a way analogous to conventional reservoir monitoring. The system will be incorporated into the SFO at the hydrate mound/salt dome complex at MC118. Benefits include the capability of long-term, continuous seismic monitoring that is marine mammal friendly through the elimination of the traditional seismic energy source.

EGL has developed and tested software that allows sensor-calibrated 4C OBS data to be used to make improved P-P and P-SV images of near-seafloor geology. The first field test of the seismic data-acquisition system was done, and shallow-water test data are now available for analysis.

Specialty Devices, Inc. has built the third sampler box for the PFA. This new box includes modifications from the original box design by enclosing the valve in an oil box to isolate it from sea-water, and by adding a new valve lever arm to allow a submersible vehicle to close the valve on the seafloor. Florida State University (FSU) is building 12 new OsmoSamplers that are due to be tested in September. The four original samplers that stayed on the sea-floor about one year longer than anticipated have been tested in the laboratory to verify their post-deployment pumping rates in order to better quantify the time series. Post-deployment rates will be used to correct the time stamp on the PFA sampler coils. All geochemical analyses of sulfate, methane, chloride, and isotopes recovered via the original PFA deployment in 2005 to investigate specific features at MC-118 identified by geophysical data have been completed. Results are being evaluated and prepared for peer-reviewed publication.

Efforts to collect high resolution pressurized pore-water samples to investigate the control of gas hydrate dissolution at MC-118 included the deployment of 6 peepers and one osmolander at MC 118 in September 2006. One peeper is located about 50cm from outcropping hydrate and about 50cm from a bacterial mat, in about 15cm of sediment. This peeper was collected in March, 2007, using the station service device (SSD). It has been analyzed for methane concentrations; 100uM closest to the hydrate, increasing to 325uM 10cm distant. Although these preliminary results counter the original hypothesis, that methane concentrations will be higher closest to the hydrate, they suggest that there is a methane sink closest to the hydrate, possibly attributable to microbial oxidation.

Efforts to analyze time-series data acquired with the storm monitor in MC118 have begun. Details of wave-noise can be recovered.

The geophysical team has concluded the discussions aimed at determining the optimal configuration of the horizontal arrays that will comprise a major component of the sea floor observatory. A revised design will be presented to DOE.

Reporting to and interacting with sponsoring agencies and their officers as well as with Consortium members is a primary administrative function of CMRET. Technical semiannual progress reports 42877R02 and 42168R18 were completed and submitted to DOE during this reporting period as were regular monthly reports documenting progress of subcontractors as well as the Consortium in general. In February, the Consortium held its annual meeting in Oxford, Mississippi. One of the most successful Consortium meetings to date, this gathering was attended by 50 members, 16 of whom made presentations (see attached Appendix), and a meeting CD including presentations by participants (both funded and not-funded), complete Consortium member contact information, an agenda, summary documents and an obituary and tribute to Hugh Guthrie, founder of the GOM-HRC Consortium concept, was distributed to meeting attendees as well as to interested parties who requested copies. Consortium administrators traveled to Boulder, Colorado at the invitation of the DOE Methane Hydrate Advisory Committee to present the activities of the Consortium and Observatory progress to that group.

The CMRET planned and executed two cruises during the reporting period: one to test the SSD and to use it for retrieval of instruments, if possible, at the Observatory site and the other to test the Borehole Array in horizontal configuration (see the appended report by SDI, Inc.). A March cruise aboard the R/V *Pelican* to test the capabilities of the Consortium-designed and built robotic Station Service Device (SSD) resulted in several successful dives and recoveries of the SSD and the retrieval of one of the FSU peepers deployed from the Johnson SeaLink in September, 2006. A June cruise to test the BHA in a horizontal configuration, included the use of the University of Southern Mississippi's R/V *Hermes* and the CMRET's R/V *Kit Jones* and shear-sled for producing shear-wave data. Monthly reports have been made to DOE each month of the reporting period.   A rewrite of Task 1 is included as Appendix B to this report.

Wall-to-Wall, an independent television programming production company, accompanied Consortium participants on the September, 2006 *Seward Johnson*/Johnson SeaLink cruise to MC118 so that they might film portions of the cruise for inclusion in a miniseries for Discovery Television. They filmed portions of the visual surveying of MC118 as well as some of the deployments, recoveries, and related activities. The Energy segment of *Building the Future* aired in June, 2007.

EXPERIMENTAL

Experiments are described in the individual reports submitted by the subcontractors.

RESULTS AND DISCUSSION

Results and discussion of those results are described in the individual reports submitted by the subcontractors. Reports from the subcontractors follow.

CONCLUSIONS

This report covers the accomplishments of the second six-month period of funding of Cooperative agreement Project #DE-FC26-06NT42877, between the Department of Energy and the Center for Marine Resources and Environmental Technology, University of Mississippi. The efforts of the Hydrates Research Consortium are reviewed: cruises to test and/or deploy instruments have been made, innovative data processing techniques developed, HLA configuration and electronics challenges resolved, a pore-fluid peeper recovered and samples evaluated, additional pore-fluid collecting devices built and others begun. Additional cruises are scheduled for retrieval of instrumentation that remains on the sea-floor. Every effort has been – and will continue to be – made to maximize Consortium members' access to and benefit from the cruises scheduled for 2007 and early 2008.

Project summaries of the subcontractors' efforts appear in their reports contained within this document. Appendices include documents relating to the Annual Meeting of the Consortium and to the Rewrite of Task1 of this Cooperative Agreement. This rewrite reflects the changes to the HLAs derived by the geophysics team and approved by DOE.

REFERENCES

Battista, B., Knapp, C., McGee, T.M., Goebel, V., 2007, Applications of the Empirical Mode Decomposition and Hilbert-Hoang Transform to Seismic Reflector Data, Geophysics, V.72, pp H29-H37.

Additional relevant references appear following contributions by the individual subcontractors.

HYDRATE RESEARCH AT THE UNIVERSITY OF MISSISSIPPI

SEMIANNUAL TECHNICAL PROGRESS REPORT
1 JANUARY, 2007 THROUGH 30 JUNE, 2007

Principal Investigator: Paul Higley

Date Issued: July 23, 2007

DOE Cooperative Agreement No. DE-FC26-06NT42877

Task 1: Design and Construction of two Horizontal Line Arrays

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Design and Construction of two Horizontal Line Arrays

ABSTRACT

The design and construction of the Horizontal Line Arrays (HLAs) for the Sea-floor Observatory (SFO) experienced three major advances in the last six months: the resolution of the Input/Output (I/O) circuitry challenges, the at-sea test of the prototype HLA, and the arrival of the geophysicists working on the design at a consensus regarding the design. Adjustments in the design will be documented in an updated Statement of Work to DOE.

BACKGROUND

The integration and application of the Input/Output Corporation's (I/O) three axis accelerometer sensor to the Horizontal Line Array is desirable as the resolution, accuracy and low frequency response of this accelerometer sensor is superior to that of marine 3-axis geophone sensors. The application of this sensor to the Sea Floor Observatory has required adapting the communications system used in its normal seismic application to the communications requirements of the Sea Floor Observatory. I/O developed this sensor as part of a highly integrated seismic system which can collect data from tens of thousands of these sensors every 10 to 20 seconds. This requires very fast data transmission for which I/O has developed a data interface that is both proprietary and elegant. The adaptation of portions of this data transmission scheme and repackaging of this data collection scheme has presented a significant challenge to the integration of the sensors into the SFO data retrieval system. Resolution of this challenge was necessary before the prototypical array could be completed and tested and, therefore, the additional arrays with which the SFO is to be equipped could be completed.

EXECUTIVE SUMMARY/EXPERIMENTAL

In an effort to simplify the data communications and control electronics I/O developed an SCI circuit card with a proprietary custom IC which combines the functions of a large amount of the custom circuitry in the recording truck. The efforts in the Spring of 2007 centered on utilizing this new approach to the problem. Both I/O and SDI wrote software to finally resolve this communications problem. The SCI card communicated directly with the present ALI cards following a software upgrade to the ALI cards. I/O completed the software upgrade in April. During May of 2007 SDI integrated the updated ALI circuitry and the new SCI card with communications software for system test and data collection. The power requirement of this system is now 12 vdc and 48 vdc. The 12 vdc will be generated from the Power Compensated Battery (PCB) and with the modification of the PCB design in 2007 to 48 vdc from 24 vdc the 48 vdc can now be supplied to the data collection array without further conversion.

The new SCI circuitry and new software cured the last of the major problems preventing the performance of a test of this technology in a format that will lend itself to installation on the sea floor. The new combination of cards and software was packaged and tested at sea with the MMRI Sled combination S and P wave source in June.

The in-water test was performed with successful recovery of accelerometer shear data generated from the MMRI developed seismic gun shear sled. This test was conducted in Biloxi, Mississippi using the University of Mississippi's R/V *Kit Jones* as the shooting boat and the R/V *Hermes* utilized as the recording boat. The test included using multiple accelerometer sensors coupled with hydrophone sensors to simulate the sensor packages to be used on a down-hole array or the earlier planned horizontal line arrays. The shear phones were installed on the sea floor with three methods of handling the coupling of the sensor to the soft mud sea floor. One sensor array was lowered to the bottom and slightly pressed into the mud bottom, one array was encased in a compartmentalized sand bag as developed by ARCO Exploration Company and one sensor array was installed and pressed approximately 2 ½ feet into the seafloor as is planned to be done by a sled-borne plow system. Multiple data lines were shot using various shot point offsets and shot spacing. The shear data exhibited excellent signal to noise ratios with the shear data from the I/O sensors appearing to have better signal to noise ratio than that from the hydrophones. Mechanical packaging was designed for housing the accelerometers and the data collection interface electronics for these accelerometers but has not been implemented as there may be the opportunity to reduce the electronics physical size in the near future.

CONCLUSIONS

Considerable support was received from Input/Output Corporation in Houston, Texas in the development of the software to function with the Input/Output electronics with both the SDI developed software package to address the SCI/ALI electronics interface and a software package from I/O becoming available on the same day. Both software packages performed well with the I/O package providing better graphics displays during data collection and the SDI package lending itself better to the planned DATS data collection platform. Further discussions with Input/Output management have led to the possibility of further refinement of the electronics to better suit the application of the Sea Floor Observatory. These refinements will include removing unnecessary functions on each circuit board and reducing the overall dimensions of the circuit boards. The reduced size will greatly affect the size of the pressure housing needed for installation at the depths of the Sea Floor Observatory.

The successful test of the HLA has removed the final obstacle to the SDI/CMRET completion of the HLAs for the Observatory. This project is likely to occupy much of the next reporting period.

Final design of the HLAs will be presented to DOE as a revised Statement of Work for this award.

REFERENCES

None.

Support of Gulf of Mexico Hydrate Research Consortium:
Activities to Support Establishment of Seafloor Monitoring Station

SEMIANNUAL PROGRESS REPORT

Reporting Period Start Date: January 1, 2007

Reporting Period End Date: June 30, 2007

Principal Investigator (Author): Bob A. Hardage

Date Issued: July 9, 2007

DOE Cooperative Agreement No. DE-FC26-02NT42877

TASK 2: Seismic Data Processing at the Gas Hydrate Sea-floor Observatory: MC118

Submitting Organization:
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Abstract

Work at the Bureau of Economic Geology during this report period focused on finishing the formulation of the software needed to create compressional (P-P) and converted-shear (P-SV) images from 4-component ocean-bottom-sensor (4C OBS) data and on testing the software at deep-water 4C OBS “lines of opportunity” that became available to the research team.

Introduction

Additional testing was done that confirms that the software created by our research team creates reliable high-resolution P-P and P-SV images of near-seafloor geology in deep-water environments.

Executive Summary

Researchers at the Exploration Geophysics Laboratory (EGL) at the Bureau of Economic Geology were subcontracted to create the deliverables for Work Task 2: Seismic Data Processing at the Gas Hydrate Sea-floor Observatory: MC118. The task assigned to EGL is to process and interpret seafloor-sensor seismic data acquired across the monitoring station. Particular emphasis will be placed on 4C OBS data acquired with receivers positioned on the seafloor and with seismic sources positioned either on the seafloor or at the sea surface. EGL scientists are writing and testing software code that will convert 4C OBS data into P-P and P-SV images of near-seafloor geology.

Experimental

Experimental activity during this period focused on developing and testing software that allows sensor-calibrated 4C OBS data to be used to make improved P-P and P-SV images of near-seafloor geology. The first field test of the seismic data-acquisition system was done, and shallow-water test data are now available for analysis.

Results and Discussion

The optimal type of seismic data needed to evaluate the hydrate system across Block MC118 is 4C OBS data. As we have waited for the seismic data-acquisition hardware and software to be constructed that will acquire seafloor-sensor data across Block MC118, we have concentrated on developing the specialized software that is needed to create high-resolution P-P and P-SV images of near-seafloor strata from data that will be acquired with this system. Our software algorithms are based on the assumption that 4C data are acquired in water depths appropriate for hydrate stability (≥ 400 meters). Our software has now been repeatedly tested on deep-water (water depths of approximately 800 meters) 4C data from the Gulf of Mexico and has consistently produced excellent images of near-seafloor geology. We consider our software development to be finished.

The finalization of our software development is well timed in that the 4C data-acquisition system developed in the project underwent its first deployment and field test three weeks previous to the writing of this report. For convenience and cost containment, these first test data were acquired in shallow water depths of approximately 6 to 8 meters, not in deep water as our algorithms assume. These test data will be analyzed by our research team during the next few weeks to determine if the data-acquisition system is ready for its true deep-water deployment in Block MC118.

Conclusions

Important seismic-imaging software that is needed to create high-resolution P-P and P-SV images of near-seafloor geology at the hydrate monitoring station has been developed and tested using 4C OBS data similar to that expected to be acquired across Block MC 118. The seismic data-acquisition system that will be deployed at MC118 underwent its first field trial in shallow water, and these test data are now being analyzed.

References

None

HYDRATE RESEARCH AT THE UNIVERSITY OF MISSISSIPPI

SEMIANNUAL TECHNICAL PROGRESS REPORT
1 JANUARY, 2007 THROUGH 30 JUNE, 2007

Principal Investigators:
Jeff Chanton and Laura Lapham, Florida State University

Associated Collaborator:
Paul Higley, Specialty Devices Inc.

Date Issued: July 11, 2007

DOE Cooperative Agreement No. DE-FC26-06NT42877

Task 3: Coupling of Continuous Geochemical and Sea-floor Acoustic Measurements

Overall Project goals

1. To calibrate seismic events, as measured with the down-hole acoustic array, with gas hydrate decomposition or formation by determining geochemical perturbations. To couple continuous geochemical sampling of pore-fluid chemistry with sea-floor acoustic and accelerometer measurements.
2. To investigate specific features at MC-118 identified by geophysical data by coring to establish vent activity by geochemical determinations, specifically, hydrocarbon concentrations, isotope ratios, and chlorinity.
3. To use high resolution pressurized pore water samples to investigate the control of gas hydrate dissolution at MC-118.

Progress toward goal 1: In order to couple geochemical sampling with sea floor acoustic measurements provided by collaborators of the Gulf of Mexico Hydrate Research Consortium, we have developed a collection device to collect pore-fluids at different depths in the sediments. This Pore-Fluid Array (PFA) is a weighted seafloor sediment probe that contains filtered probe ports along a shaft which are interfaced to a pore fluid sampling instrument package via a low dead-volume connector (Figure 1). Deployed from a surface ship, the PFA probe tip is inserted into the sediment under its own weight. The hollow steel probe shaft (10m long x 7.6cm square) contains eight evenly spaced filtered sampling ports (Figure 1a and 1d). Small diameter tubing from each port runs the inside length of the shaft to a customized connector (Figure 1b; developed by Paul Higley, Specialty Devices, Inc.). This zero dead-volume connector is keyed to interface each sampling port to an individual pore-fluid sampler housed within the instrument package. It allows a remotely operated vehicle to replace the instrument package periodically without removing the probe shaft from the sediments, thus minimizing disruption of sample collection between each visit. The pore-fluid instrument package (Figure 1c) is made up of four OsmoSamplers [*Jannasch et al.*, 2004] and a high pressure valve. The PFA was first placed on the northern portion of the mound of MC 118 in May 2005 (Figure 2). The sampler box was collected in September 2006 and four of the samplers were analyzed for sulfate, chloride, and methane concentrations (results in the October 2006 to March 2007 report).

In the last 6 months, we have built the third sampler box (Specialty Devices, Inc.), are in the process of building 12 new osmosamplers at the FSU machine shop, and have tested the OsmoSamplers collected during the first deployment of the PFA sampler box. Each of these tasks will be discussed fully below.

Built modified sampler box: In the last 6 months, our associated collaborators at Specialty Devices, Inc. have built the third sampler box. This new box includes modifications from the original box design by enclosing the valve in an oil box and by adding a new valve lever arm (compare old box versions to new version in Figure 3). In the first deployment of the PFA and sampler box, the stainless steel valve was exposed to seawater (Figure 3b). As this is not ideal for metals to be exposed to seawater, the valve was enclosed in an oil box (Figure 3c). A lever arm was also added to the valve body to allow a submersible vehicle to easily close the valve on the seafloor.

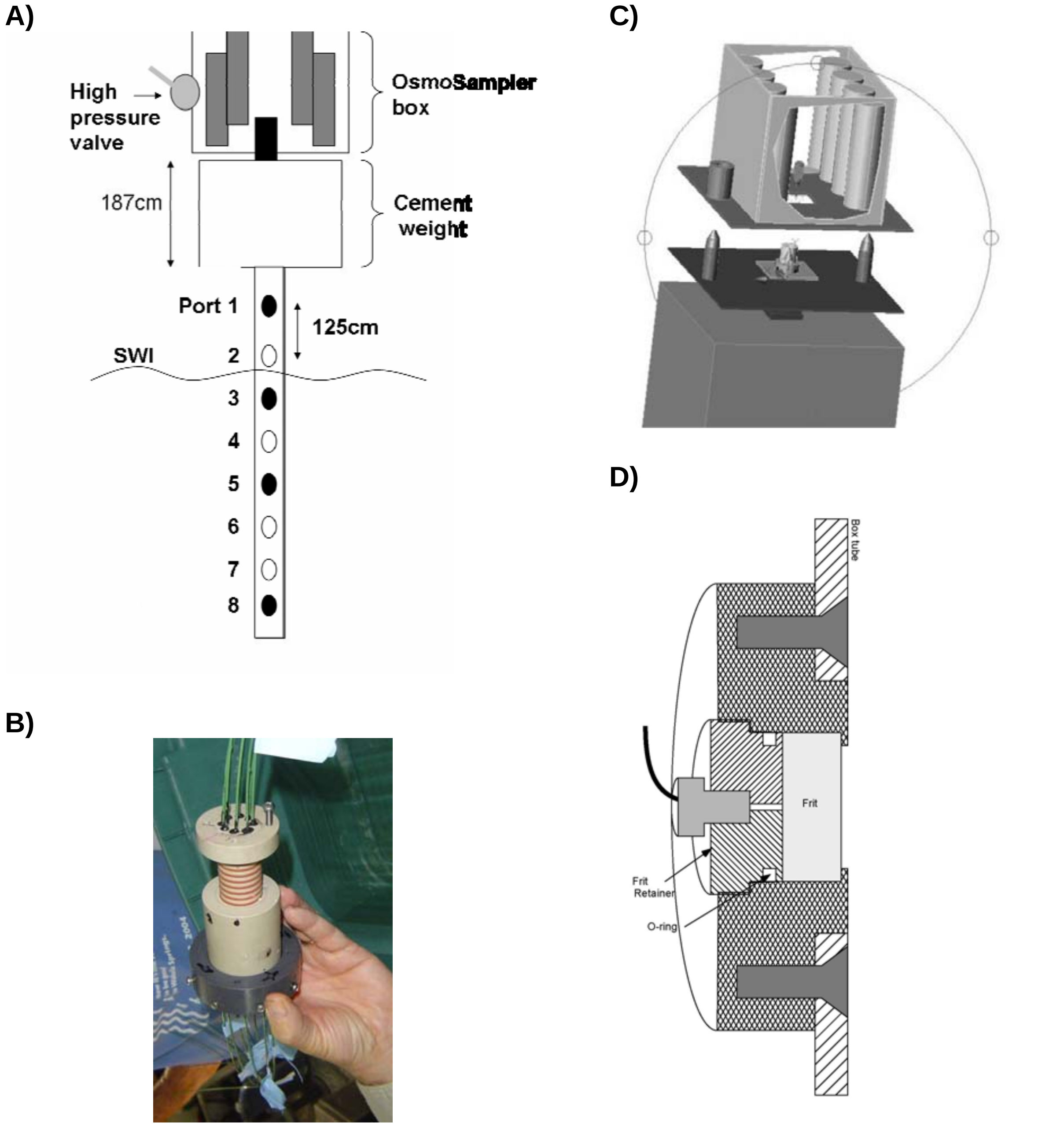

Figure 1: Components of the Pore Fluid Array. A) Conceptual picture of the PFA with instrument package containing OsmoSamplers (gray) with valve on left side of box (light gray), connected to cement weight with the keyed connector (black), and the 10m probe tip. White circles signify sampling ports used, black circles were not used. Sediment depths were determined by the circumstances of deployment. B) Actual picture of the keyed connector. C) Osmosampler basket mated to the cement weight via the connector. D) Cross-section of sampling port in side of probe.

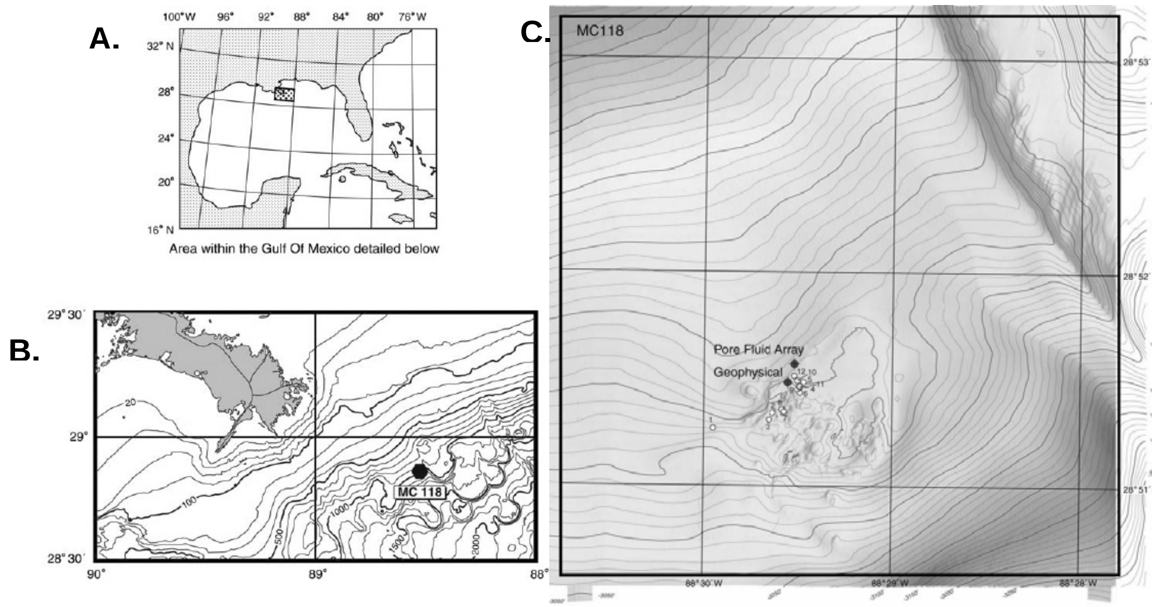

Figure 2: A. Gulf of Mexico showing sampling site in shaded range. B. Contour map showing MC 118 offshore Mississippi River birdfoot delta. C. Mississippi Canyon 3 mile x 3 mile lease block 118 showing site of pore fluid array and geophysical array. White dots show cores collected in 2005.

Building new osmosamplers: Currently, twelve new OsmoSamplers are being built at the FSU Oceanography Machine Shop. Construction will be completed in August 2007, laboratory testing will commence in September, 2007.

Laboratory tests on OsmoSamplers: OsmoSamplers collect pore-fluids slowly over time using an osmotic differential created between a brine and DI-water reservoir within the pumps (Figure 4). Therefore, the pumping rate is dependent upon the in situ temperature as well as the concentration gradient between the brine and DI water reservoir.

The PFA OsmoSampler box was first deployed at MC 118 in May 2005. Due to weather considerations beyond the control of the Consortium, the box was not retrieved from the seafloor until September 2006. At this time, the samplers had overpumped their coils, affecting their original pumping rates. Therefore, we tested the four original samplers in the laboratory to verify their post-deployment pumping rates in order to better quantify the time series. As expected, the rates were lower after deployment than before (Table 1). These lower pumping rates were due to the pumps over-pumping with seawater during the deployment which effectively lowered the concentration gradient between the brine and DI water reservoir. This is shown when we plot the pumping rate to the concentration of chloride measured within the DI water reservoir (Figure 5). These post-deployment rates will be used to correct the time stamp on the PFA sampler coils.

A) B) C)

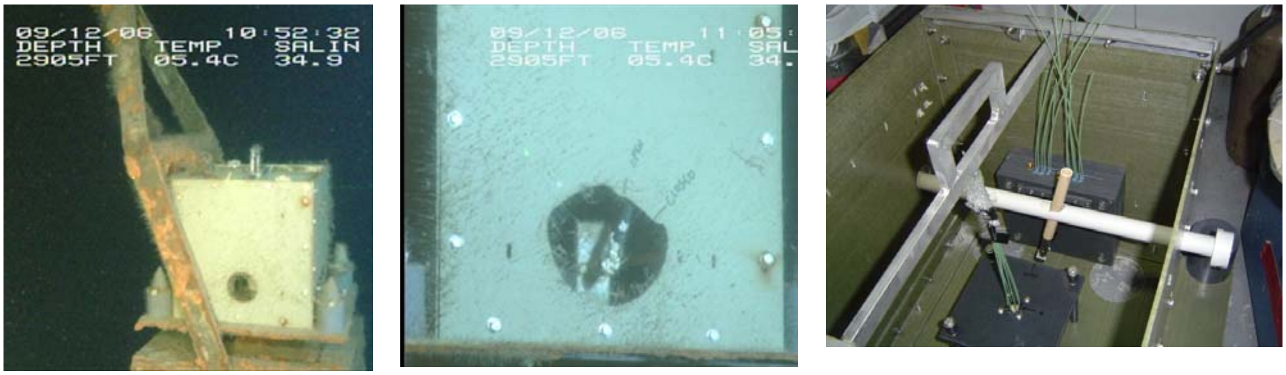

Figure 3: A) The OsmoSampler package shown on the seafloor with minimal biofouling and all parts intact. B) Close up of the original valve exposed to seawater. C) Modified sampler box with valve enclosed in oil box (gray box with green tubes emanating from it) and manual lever arm (white PVC tube) for ease of closing on the seafloor.

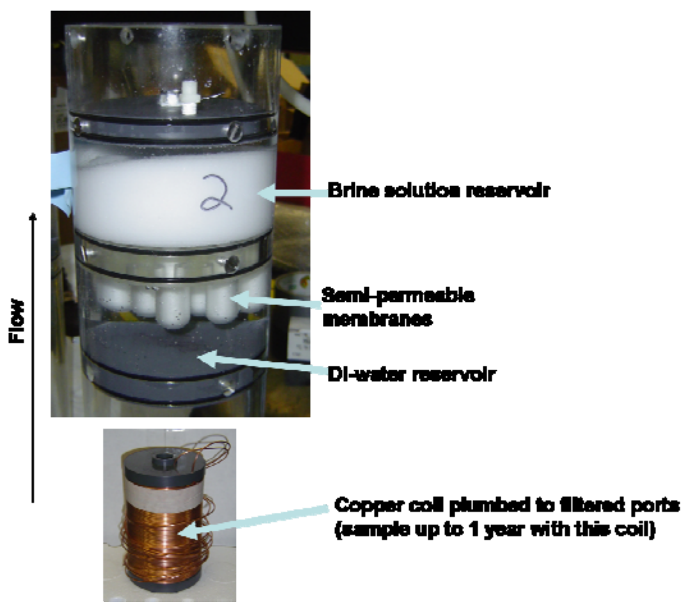

Figure 4: Picture of OsmoSampler and copper tubing spool (Jannasch et al., 1994; Jannasch et al., 2004).

Progress toward goal 2: All geochemical analysis of sulfate, methane, chloride, and isotopes has been completed to investigate specific features at MC-118 identified by geophysical data. Therefore, we are writing up these results for peer-reviewed publication.

Table 1: Average pumping rates at 25ºC for four OsmoSamplers prior to and after deployment

Pump #	1	2	3	4
Prior to deployment	1.00±0.27	0.89±0.32	0.97±0.23	na
After deployment	0.19±0.05	0.68±0.04	0.97±0.02	na

Progress toward goal 3: These last 6 months, we have made great strides to collect high resolution pressurized pore water samples to investigate the control of gas hydrate dissolution at MC-118. We deployed 6 peepers and one osmolander at MC 118 in September 2006. One of those peepers was located at Mandyville, ~50 cm horizontal distance away from outcropping hydrate and about 50 cm away from a thick, white bacterial mat (Figure 6). The peeper was placed in about 15 cm of sediment. In March 2006, we collected this peeper and analyzed for methane concentrations. Closest to the hydrate, concentrations were 100 uM and increased to 325 uM 10 cm away (Figure 7). Although these preliminary results oppose our original hypothesis, that the concentrations are higher closest to the hydrate, they suggest that there is a methane sink closest to the hydrate, possibly microbial oxidation. Further testing of the isotopic signature of this methane will help understand the processes involved in giving this result. These results will also be verified with future collection and analysis of other peepers deployed at the hydrates.

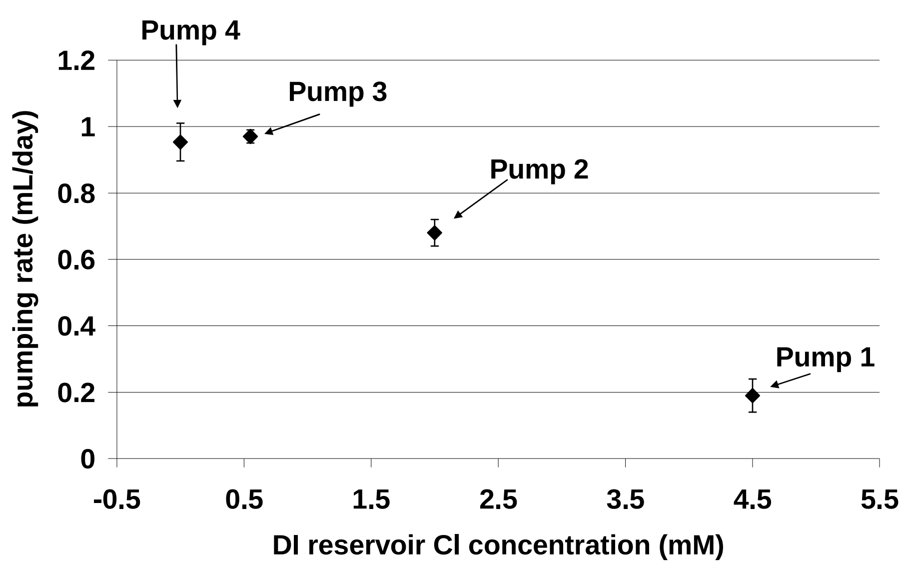

Figure 5: Graph of DI water reservoir chloride concentration versus pumping rate.

Future work: In July 2007, there is a hydrate consortium cruise planned to visit MC 118. On this cruise, we will utilize the service station device (SSD) remote vehicle to collect 5 remaining peepers at both Rudyville and Noakesville. Also at Rudyville, we will retrieve the osmolander, also intended to collect an *in situ* methane concentration gradient from hydrate. And finally, we will retrieve the second PFA osmosampler box and replace it with the third box.

References:

Jannasch, H. W., et al. (2004), Continuous chemical monitoring with osmotically pumped water samplers: OsmoSampler design and applications, *Limnology and Oceanography: Methods*, *2*, 102-113.

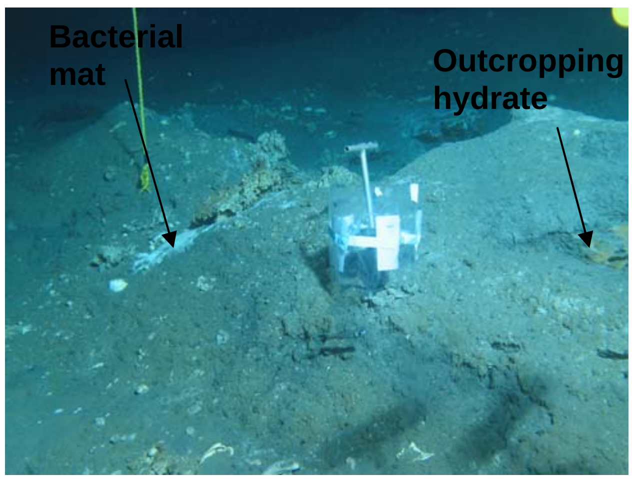

Figure 6: Picture of bagged peeper at Mandyville.

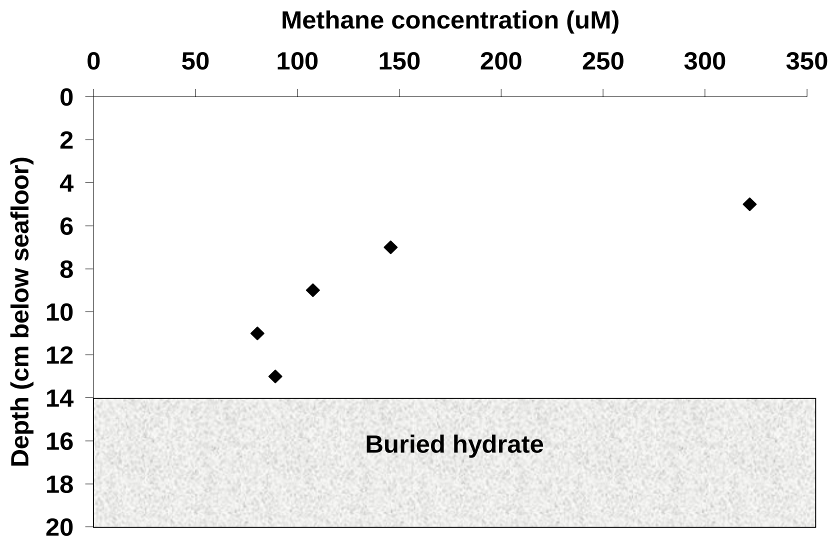

Figure 7: Methane concentrations with depth at Mandyville. The peeper was located 1 cm above a buried hydrate.

HYDRATE RESEARCH AT THE UNIVERSITY OF MISSISSIPPI

SEMIANNUAL TECHNICAL PROGRESS REPORT
1 JANUARY, 2007 THROUGH 30 JUNE, 2007

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Date Issued: June 30, 2007

DOE Cooperative Agreement No. DE-FC26-06NT42877

Task 4: Noise-Based Gas Hydrates Monitoring:
Monitoring gas hydrates by extracting Green's functions from noise

Abstract

Monitoring of gas hydrates at Mississippi Canyon 118 is possible using ambient noise as a sound source. The goal is to attempt to apply passive methods to supply information similar to that supplied by active sources, but on a continuous basis as passive sources, such as wave-noise, are everpresent at MC118.

Introduction

By using ambient noise-based methods with dense networks, passive monitoring of gas hydrates is possible. Making use of ambient-noise cross correlation function of diffuse fields between two receivers, information can be recovered that is similar to that recovered using an active source.

Executive summary

A first-year graduate student has been assigned to this project. He started in September 2006, so his main focus is on class-work.

There has been some effort in analyzing time series from tropical depression Alberto. These data were acquired with a storm monitor deployed at Mississippi Canyon 118 in June, 2006, and recovered in March, 2007. Examples of recovered data appear in Figs. 1 and 2.

Experimental

Efforts to analyze time-series data acquired with the storm monitor in MC118 have begun. Already, however, as the following images show, details of wave-noise can be recovered.

The principle investigator is a key participant in the discussions aimed at determining the optimal configuration of the horizontal arrays that will comprise a major component of the sea floor observatory. This effort is, essentially, resolved and therefore, complete. It is the subject of the poster prepared by Tom McGee for the hydrates observatories workshop in Portland, Oregon in July, 2007.

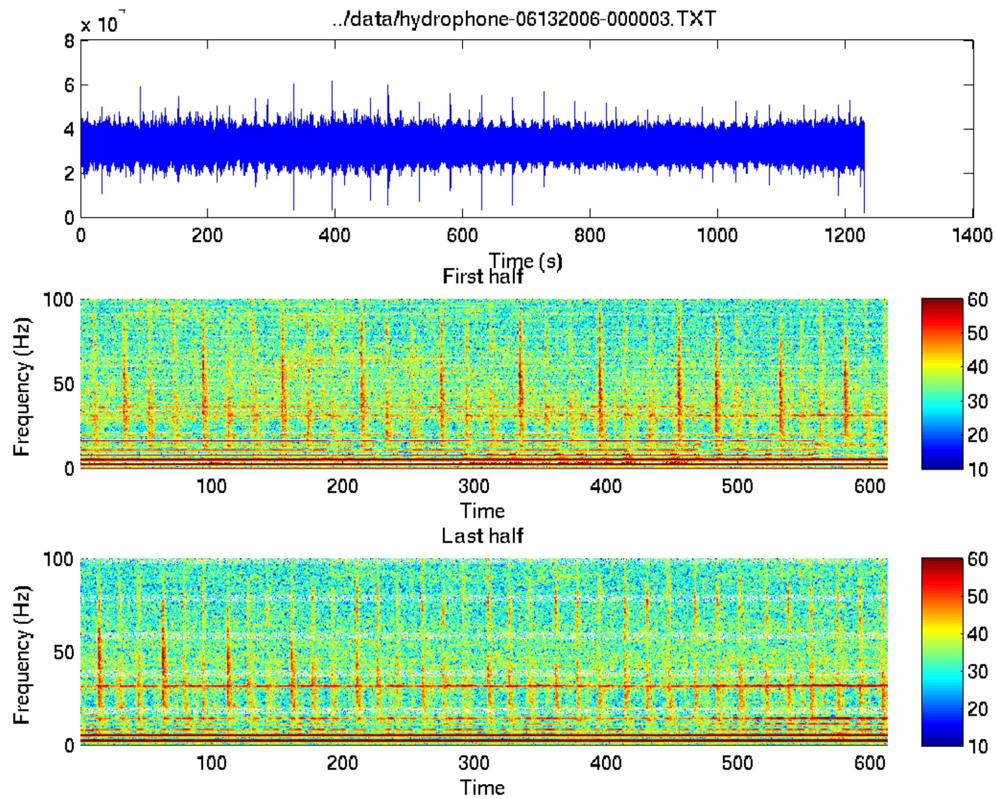

Figure 8. Times series and spectrogram for frame 35 (14 June 18:00)

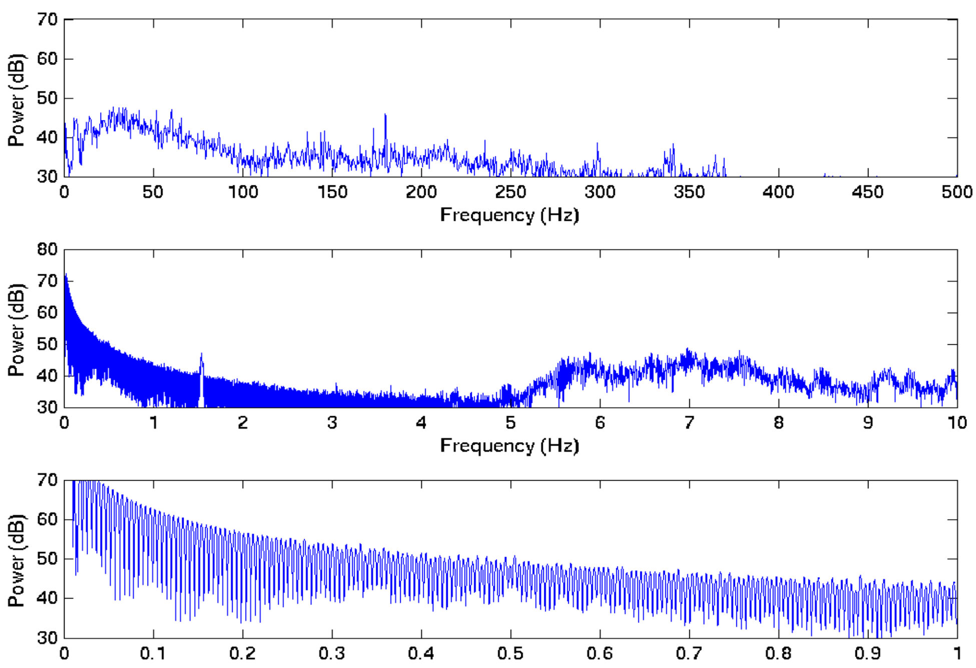

Figure 9 Spectrum for frame 35 (14 June 18:00)

Conclusions

The student is progressing toward the capability of working with experimental data while continuing with his classwork. The time-series data show promise of providing a true monitoring capability at MC118.

ACRONYMS AND ABBREVIATIONS

3-D	three-dimensional
4-C	four component
ALI	A-Link interface (Input/Output's combination of units; accelerometer pseudo-ethernet communications interface and timing device)
AUV	autonomous underwater vehicle
BBLA	Benthic Boundary Layer Array
BEG	Bureau of Economic Geology (University of Texas)
BHA (=BLA)	borehole array
BLA (=BHA)	borehole line array
C&C	Chance and Chance
CD	compact disk
CSA	Chimney Sampler Array
CTD	conductivity, temperature, depth (sensors)
CMRET	Center for Marine Resources and Environmental Technology
DATS	Data Acquisition and Telemetry System
DI	deionized
DOC	Department of Commerce
DOE	Department of Energy
DOI	Department of the Interior
DTAGS	Deep-Towed Acoustics/Geophysics System
DRS	Data Recovery System
EGL	Exploration Geophysics Laboratory
FSU	Florida State University
FY	Fiscal Year
GC	gas chromatograph
GC-TOF	gas chromatograph Time of Flight (mass spectrometer)
GLA	geophysical line array
GOM	Gulf of Mexico
GOM-HRC	Gulf of Mexico-Hydrates Research Consortium
HLA	horizontal line array
HRC	Hydrates Research Consortium
HSZ	Hydrate Stability Zone
IDP	Integrated Data Power Unit
IC	integrated circuit
I/O	Input-Output
JIP	Joint Industries Program
MC	Mississippi Canyon
MMRI	Mississippi Mineral Resources Institute
MMS	Minerals Management Service
uM	micromolar
MS	monitoring station
NETL	National Energy Technology Laboratory
NIUST	National Institute for Undersea Science and Technology

NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OBS	ocean-bottom sensor
OBC	ocean-bottom cable
OLA	Oceanographic Line Array
PCA (=PFA)	pore-fluid array
PCB	pressure-compensated battery
PFA (=PCA)	pore-fluid array
P-P	compressional wave mode
P-SV	converted-shear mode (P-wave to SV-shear wave conversion)
pvc	polyvinyl chloride
P-wave	compressional wave
ROV	remotely operated vehicle
rna	ribo-nucleic acid
R/V	Research Vessel
SCI	serial communications interface
SDI	Specialty Devices, Inc.
SFO	Sea Floor Observatory
SFP	Sea Floor Probe
SSD	Station Service Device
SS/DR	Surface-Source Deep Receiver
STRC	Seabed Technology Research Center
S-wave	shear wave
UCSD	University of California at San Diego
UNC	University of North Carolina at Chapel Hill
US	United States
USGS	United States Geological Survey
vdc	volts direct current
VLA	vertical line array

APPENDIX A: ANNUAL MEETING OF THE CONSORTIUM

AGENDA

GULF OF MEXICO HYDRATES RESEARCH CONSORTIUM
ANNUAL MEETING
The University of Mississippi E.F. Yerby Center
Oxford, Mississippi
February 27-28, 2007

Hosted by:
The Center for Marine Resources and Environmental Technology and
The National Institute for Undersea Science and Technology's
Seabed Technology Research Center at
The University of Mississippi

AGENDA

Tuesday, February 27, 2007

8:00 am - Gather at the Yerby Center
Speakers, please load and save your presentations onto the computer.

8:30 am – Welcoming Remarks Bob Woolsey, Director, The Seabed Technology Center and Center for Marine Resources and Environmental Technology, University of Mississippi

8:40 am – Opening of the Consortium Meeting Alice Clark
Office of Research and Sponsored Programs, University of Mississippi

8:50 am –Program Update Bob Woolsey and Tom McGee, CMRET, STRC

9:10 am – Comments from federal agency representatives Roger Amato, MMS
Rick Baker, Traci Rodosta, DOE
Gene Smith, NURP

9:30 am - *Design, deployment, and recovery of the Pore-Fluid Array to measure in situ methane, chloride, and sulfate concentrations at MC 118: Discovery of brine and thermogenic methane* Laura Lapham and Chris Martens, UNC-Chapel Hill
Jeff Chanton, Florida State University
Paul Higley, Specialty Devices, Inc.
Bob Woolsey, University of Mississippi

9:45 am - *Deployment and results from the CSA/BBLA hydrate observatory sensor arrays*
Christopher S. Martens and Howard Mendlovitz, UNC-Chapel Hill
Rich Camilli, Norm Farr and Oscar Pizzaro, Woods Hole Oceanographic Institution
Jeffrey P. Chanton, Florida State University

10:00 am - *In situ mass spectrometry data from MC118* Rich Camilli and Norm Farr
Wood's Hole Oceanographic Institution

10:30am – BREAK (Coffee and Pastries provided by Bottletree Bakery)

11:00 am – *Infrared Analysis of MC118 Core Samples* Gary Dobbs
Georgia Institute of Technology

11:15 am – *Designing a visual reconnaissance strategy for the hydrate observatory*
Ian R. MacDonald
Texas A&M University - Corpus Christi

11:30 am - *Opportunities at MC118 using the DTAGS* Warren Wood
Naval Research Laboratory, Stennis Space Center

11:45 am - *Marine electromagnetic methods for gas hydrate characterization*
Karen Weitemeyer and Steve Constable
Scripps Institution of Oceanography, La Jolla, CA

12:00 noon – LUNCH (on-site, provided by McAlister's Deli)

1:00 pm – *The Station Service Device: a Novel Tool* Paul Higley
Specialty Devices, Inc.

1:15 pm - *Analysis of Green Canyon resistivity logs that traverse the hydrate stability zone*
Bob Hardage
Bureau of Economic Geology, University of Texas, Austin

1:30 pm - *Electrical Resistivity Investigation of Gas Hydrate Distribution in Mississippi Canyon Block 118, Gulf of Mexico* John Dunbar
Baylor University

1:45 pm – *Monitoring Hydrates using ambient noise* Peter Gerstoft
University of California – San Diego

2:00 pm - *When Katrina Hit California* Peter Gerstoft
University of California – San Diego

2:15 pm – BREAK

2:45 pm - *Microbiology and biogeochemistry of gas hydrate and associated sediments from MC118* Mandy Joye
University of Georgia

3:00 pm - *Microbial community structure and geochemical gradient results in shallow sediment cores from MC118 based on ribosomal RNA and functional genes*
Andreas Teske
University of North Carolina – Chapel Hill

3:15 pm - *Microbial dynamics in water column and sediments at MC 118* Chuanlun Zhang
Savannah River Ecology Laboratory, University of Georgia

3:30 pm - *Microbe-Mineral-Hydrate Interactions* Rudy Rogers
Mississippi State University

3:45 pm - *Status of the Southern Miss Accomplishments: the Eagle Ray AUV capabilities and the Electromagnetic Bubble Sensor* Vernon Asper, Director NIUST's
Undersea Vehicle Technology Center, University of Southern Mississippi

BREAK-OUT SESSIONS:

- Site Characterization – MC118 – identify gaps.
- Geochemistry at MC118
- Microbial Activity at MC118 – Special Publication?
- Design and Construction of the Horizontal Line Arrays
- Cruise needs: March Pelican cruise, March NR-1 cruise, July Pelican cruise, etc.
- Other?

Wednesday, February 28, 2007

8:30 am - Reconvene at the Yerby Center. Small group sessions will break out according to Tuesday's accomplishments and remaining tasks. Small groups will prepare to make brief reports to the larger group before the close of the meeting.

Break-out sessions

11:00 am - All meeting participants reassemble to discuss status of the station.

Lunch provided by H_2O, Oxford Oriental Café.

Reconvene in whatever configuration is most productive.

ACCOMPLISHMENTS - February, 2007

Several events this month provide landmarks for the development of the Gulf of Mexico sea-floor observatory. Additional trials of the Station Service Device took place at the NOAA/NMFS test tank, Stennis Space Center, February 4.

The Gulf of Mexico Hydrates Research Consortium, administered by the Center for Marine Resources and Environmental Technology (CMRET) at the University of Mississippi, held its Annual Meeting in Oxford, February 27-28. At this meeting, researchers funded by the Consortium presented results of their recent research efforts and planned how and in what order the tasks remaining to complete the observatory, should be addressed.

Recent findings include:

Geophysical – Accomplishments

a. A complete surface-source/deep-receiver survey of the mound at MC118 has been completed.
b. SS/DR data have been analyzed and preliminary processing completed.
c. A 3-D model of the mound showing areas of gas concentrations is emerging.
d. Software that will enable scientists to make use of industry standard seismic records has been completed and tested.
e. The use of surface noise as a source has been established.
f. The utility of resistivity methods to define the gas hydrate stability zone has been demonstrated.

Geophysical – Goals

a. The SS/DR data will be reprocessed and a complete 3-D model of the mound at MC118 built.
b. Resistivity studies and DTAGS surveys are scheduled for MC118.
c. Vertical and horizontal array data must be recovered from MC118.
d. A fiber-optic link to the observatory site needs to be established.

Geochemical - Accomplishments

a. In situ cycloid mass spectrometer data, geochemical hydrocarbon distribution data and osmosampler results indicate that the northern site is substantially different from the southwestern site.
b. North site has brine at depth, southwest site likely does not.
c. North site has significantly less higher hydrocarbons than SW site.
d. North site is dominated by microbial mats and soft flat sediments with small carbonate nodules and chimneys while the SW site has extensive relief, gravel and shell hash, massive blocks of exposed hydrate and carbonate and the presence of higher hydrocarbons e.g., more ethane, propane, butane, and other higher (oil fraction) hydrocarbons.
e. Sulfate reduction rates extreme.
f. Osmo sampler (PFA, pore fluid array) a great success, temporal data set obtained, brine found at 8 meters depth. Replacement sampling head installed.

g. Methane concentrations in sediments surrounding gas hydrates are consistently below thermodynamic equilibrium indicating kinetic control of gas hydrate stability and dissolution.
h. Significant temperature variability at the site on the order of 0.1 to 0.2 C over a 12 hour period. At 4 m in seafloor, temperature more stable, and warmer than overlying seawater values.
i. Variations in gas flux appear to be related to tidal cycle.
j. At the SW site, significant variations of hydrocarbon composition were observed over short length scales (c1 to c3).
k. Variation in carbonate mineralogy confirmed salinity/brine variations observed with PFA between site 4 North and site 1 SW.

Geochemical - Goals
a. PUBLISH Results (main and most immediate goal).
b. Determine controls of hydrate stability in terms of dissolved methane concentration (thermodynamic versus kinetic) by in situ methane concentration determination in sediments immediately adjacent to hydrate deposits. A variety of approaches will be used including different types of pore water equilibrators and osmosamplers.
c. Place additional osmosamplers to monitor spatial and temporal variations in pore water hydrocarbon and chlorinity across the feature.
d. Explore the other three main target sites associated with the feature, specifically sites 2,3 and 5. Sites 2 & 3 are southeast sites located due E of target site 1. Site 5 is directly between 1 and 4, central location. These sites must be characterized in terms of hydrocarbon and methane geochemistry, salinity and other factors.
e. Continue efforts to unify the geophysical with geo-chemical data.
f. Re-navigate position estimates on the dives to better geo-reference in situ chemical measurements and imagery.
g. Continue analysis of water samples to resolve unknown GC (gas chromatograph) peaks with more powerful techniques, GC-TOF MS (mass spectrometer).
h. Repair BBLA (benthic boundary layer array and CSA following significant damage during return transport.
i. Integrate ethernet capability to BBLA and CSA and adapt for external battery power source from observatory (IDP).
j. Prepare for next deployment and identify sites of interest.
k. Obtain heat flow data and monitor thermal gradients versus depth at the site.

Microbiological – Accomplishments
a. Documented for the first time microbial activity – both sulfate reduction and anaerobic oxidation of methane – in ‘in tact’ gas hydrate.
b. Very high rates of sulfate reduction were observed in these sediments.
c. Very low rates of methane oxidation (consumption) were observed.
d. Sediments near hydrate mounds show rapid consumption of sulfate over depth (by 15 cmbsf) and are gas charged.
e. The magnitude of sulfate reduction rates at MC118 appears to be driven by oil oxidation—rates are higher at South MC118, where sediments contain large amounts of oil (sediments at North MC118 area do not contain so much oil).

f. *Beggiatoa* mats as indicators of subsurface fluid upwelling and methane-oxidizing microbial communities:

- indicate hot spots of active sulfate reduction and methane oxidation.
- methane-oxidizing archaea and sulfate-reducing bacteria are active underneath the mat.
- extensive mats indicate a plateau of upwelling subsurface fluids, not a dome-shaped plume.
- geochemical gradients in mat center and margins are similar and don't follow domed contour lines.
- small mats have irregular subsurface fluid flow paths (no defined upwelling "plateau").

Microbiological – Goals

- Complete molecular biological analyses of sediments obtained during September 2006 cruise.
- Obtain deeper cores from MC118 South to better characterize the distribution of microbial groups and processes over extended depth (~3m).
- Conduct laboratory experiments aimed at elucidating controls on microbial activity in these sediments.
- continue to map the distribution of methane oxidizers and sulfate reducers in the sediments underlying *Beggiatoa* mats, to investigate the metabolic coupling between *Beggiatoa* mats and anaerobic communities in the sediment (producing CO_2, LMW org. acids and hydrogen sulfide, all suitable substrates for *Beggiatoa*). We aim at a complete molecular/geochemical gradient dataset for selected deep cores and for shallow mat cores (Sept. 2006).
- Finish sequencing and rate measurements.
- Retrieve apparatus from Microbial / Hydrate Observatory site at MC-118 during upcoming cruise.
- Continue work of the microbe-mineral-hydrate interactions.

APPENDIX B: Rewrite of Task 1

TASK 1: Design and Construction of four Horizontal Line Arrays
(Subcontractor: Specialty Devices, Inc. (SDI))

In order to establish a fully functional 3-dimensional imaging observatory, the MS/SFO must contain more than a single point where subsurface data are collected. HLAs have been determined to be the most appropriate means of doing so. The recipient shall undertake activities necessary to design and construct four (4) hydrophone-only HLAs. In addition, the configuration of the arrays will be designed to maximize the likelihood that they may later be useful for monitoring seismic events and hurricanes.

Subtask 1.1: Design of the Horizontal Arrays
With input from other geophysicists working on the Consortium MS/SFO, the recipient will determine and document the final configuration of the HLAs required to meet observatory needs.

Subtask 1.1a: The Recipient shall define experimental configuration of components, spacing, and usefulness of data for the HLAs based on results of HLA sea-floor tests (being conducted under separately funded consortium research).

Subtask 1.1b: The Recipient shall refine and finalize the HLA design based on results of tests (being conducted under separately funded consortium research) using the JIP borehole array in HLA configuration to collect compressional (P-wave) and shear-wave data from the sea-floor.

Subtask 1.2: Construction of Horizontal Line Arrays (4)
The Recipient shall conduct activities necessary to construct and test four (4) HLAs meeting the functionality and configuration requirements defined from the results of subtask 1.1

Subtask 1.2a: The Recipient shall conduct activities required for the purchase and assembly of all components of the arrays required to meet the defined functionality and configuration requirements.
Subtask 1.2b: The Recipient shall construct pressure housings (or other equipment as required) for all sensors as necessitated by the anticipated system operating environment. The recipient shall conduct pressure-testing of the system prior to deployment to demonstrate suitability for deployment conditions.

Subtask 1.3: Deployment of the four HLAs
The recipient shall conduct activities necessary to: deploy four (4) HLAs, complete with data-loggers (MMS-funded) at the MS/SFO site, incorporate HLAs into the station by connecting to the Integrated Data Power Unit (IDP), and test data collected from HLAs.

Final Products: Four hydrophone arrays deployed on the surficial deposits of the sea-floor at the MS/SFO at MC118, capable of collecting compression-wave data and sending them to the IDP.

MONITORING STATION SYSTEMS STATUS SUMMARY

Geophysical Sensor Systems

The geophysical sensor systems concept has evolved since its original conception, as has been described in earlier proposals and reports, primarily in response to changing circumstances and advancements in geophysical technology. Briefly, the original plan for a net of five 200m water-column vertical line arrays (VLAs) or acoustic line arrays (ALAs) gave way to a plan for a single ALA located in close proximity to four horizontal line arrays (HLAs) laid out in a cross pattern on the seabed. The advantages include better location of noise-generating ships of opportunity providing P-wave energy for the hydrophones of the ALA and HLAs. Further, the cross pattern of the HLAs could be used in experimental work with natural surface noise, such as wind-driven waves, as an acoustic energy source.

Plans for access to one or more boreholes for the installation of at least one bore-hole vertical line array (BLA) thus far have proven elusive. Beginning in the spring of 2003, communications with the Joint Industry Program (JIP) gave hope to accessing a site in Atwater Valley. Regrettably, the 1300m water depth at the site proved too great a challenge for the various sensor technologies currently available to the Consortium, as well as funds available for the project. More recently, plans to core, log and emplace down-hole arrays at the observatory site, MC118, were aborted when a change in drilling vessels available to the JIP forced cancellation of planned operations at MC118. CMRET researchers, however, are in frequent contact with the JIP and continue to be involved in plans for drilling projects in the Gulf of Mexico. Since there will not be a 2006 JIP drilling project, the earliest possibility for a JIP borehole in MC118 is now sometime in 2007. Should the March, 2006, bid to lease MC118 be accepted by MMS, another possibility will be to try to work with the new leaseholder's site evaluation team as their coring and logging operations begin.

In the meantime, the concept of utilizing Sea-floor Probes (SFP) to emplace 4-C seismic arrays has been revisited. In spring, 2005, a gravity driven version of the SFP was used to emplace a 10m geophysical line array (GLA), so the capability is in-hand. The GLA will serve as a good test instrument until such time as it can be replaced with the larger (150m) DOE-funded BLA. The request for funding for the HLAs is contained in this proposal. The needed data-loggers are on the list of equipment requested from Minerals Management Services in this funding cycle (July 1, 2006-June 30, 2007) while the funding for the associated hydrophones has been requested from STRC. Please see Figures 1 and 2 for the current conceptual configuration of the MS/SFO and for a breakdown of sensor systems by funding agency.